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PUBLIC WORKS REFORM

IN

INDIA.

BY

LIEUT.-COL. TYRRELL,

MADEAS ARMY,

FORMERLY EXECUTIVE ENGINEER PUBLIC WORKS DEPARTMENT.

Si quid novisti rectius istis,
Candidus imperti; si non, his utere mecum.

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P R E F A C E.

THE Author has ventured to publish this small volume in the hope that it may contain some idea that may be found useful in promoting the efficiency of the Public Works Department in India. He is aware that it is very superficial and entirely incommensurate with the importance of the subject. The magnitude of the interests at stake, and the dependence of so many millions on the efficient working of that department in India, have induced the Author to snatch what time he could from extensive farming operations, in order to contribute his mite towards so important a subject. He trusts that it may induce others with more knowledge and more skill to ventilate the subject further.

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NOTE TO PAGE 13.

Vide *Public Works and the Public Service in India*, by
MAJOR EVANS BELL and LIEUT.-COL. F. TYRRELL.

PUBLIC WORKS REFORM IN INDIA.

It is, I believe, too common an idea in England, that the natives of India are without an engineering history, that there are no works extant of their engineering skill, and that they owe to us all that they possess in that department: such is not the case. India *has* an engineering history; not written in splendid palaces and lofty structures, yet still marked by works whose usefulness may vie with works of any other nation—works on which her life depends.

Some parts of India, particularly the south,—are covered by a network of tanks; they are found, however, all over India, and the ruins of some bear witness to their immense size. Their number, and extent, and presence all over India, prove the general idea that was felt of their necessity. In order to give some notion of their size, I give the dimensions of four large tanks now in existence; there are, however, larger ones, but I have not any statistics of them by me.

District.	Name of Tank.	Height of Band.	Length of Band.	No. of Villages Watered.	Annual Average Revenue to Go- vern't.
		Feet.	Miles.		Rs.
Mellore ...	Cunnigherry tank	20	2	23	78,000
North Arcot	Cauvenpaukum tank ...	45	4	23	43,000
Chungleput	Chumbrumpaukum tank	25	3½	58	49,000
South Arcot	Veeraunum tank.....	21	9	149	114,500

In the Nagpoor and Hyderabad country of the Deccan, the ruins of extremely large tanks exist, now in the midst

of jungles, formerly the sites of a rich cultivation and a busy population. To the east of Hyderabad in the Decan, and of Nagpoor, and even as far east as the Boad Country in Orissa, these remains are numerous—showing that at one time, even in those wild tracts (where at present there is little besides jungle) there was a thriving people.

The ancient engineering works of India in the south are, with the exception of tanks, neither very numerous nor well executed. The ancient Hindoo buildings are, in fact, more curious than works of engineering skill; they are, in many instances, extremely solid and strong, but the arch is seldom met with. Huge stones cover their temples, as in Humpee or Beejanuggur, founded by Virjza Ragu, A.D. 1119, on the banks of the Toongabudra; some of these measure twenty-four feet long by four feet wide, by one and a half thick. The chief attraction of the ancient Hindoo temple is, however, generally the elaborate carvings of figures, etc. The old bridges met with in India are not built on very scientific principles. These generally rise very high in the centre, with a gradient often of 1 in 6 to 1 in 10; there is generally a great want of waterway, and the approaches are often covered with water during floods. The old annicuts on the Coleroon and Toongabudra and other rivers are not neat constructions; they, however, gave us the idea, and are the foundation of our most successful irrigation works. The chief works executed by the old Hindoo rulers were tanks, of which there are thousands; many silted up, many in ruins, many dry by destruction of the supply channels. The investigation of the tank system of India, and the repairs and construction of tanks, is a matter that was brought to notice of Government strongly, vehemently, and repeatedly, by Captain A. Cotton (now Sir A. Cotton) in 1837, and constantly since by that eminent officer; it was backed by the Report of the Commission on the Public Works Departments in 1851, and all experience has tended to prove the soundness of those views, yet up to this time nothing has been done commensurate with the importance of the subject. I could myself point out

more than a hundred tanks that are in ruins ; tanks that must have originally irrigated many hundred acres of land, and would probably in the aggregate water at least three thousand villages.

In Central India, and towards Bombay, we have many curious works, but not very instructive in an engineering point of view ; such are the tombs of the Ghond Kings at Chanda, the forts of Gawilghur and Narnulla on the Satpoora range of hills, about three thousand feet above the sea, built extremely massively of black basalt, quarried on the spot ; the lime must have been all brought up from the plains with great labour on the backs of bullocks. These forts were taken by Lord Wellesley in 1803. We have then the caves of Adjunta and Ellora, near Roza, and the caves of Elephanta in the Harbour of Bombay ; the former were doubtless used by the Brahmins for religious purposes, and at an earlier period by the Buddhists. They have, however, always struck me as being originally of Egyptian origin. The capitals of the most ancient columns have a strong resemblance to the Egyptian form, and the paintings which formerly covered the caves of Adjuntah were painted on a material and with pigments exactly corresponding with those found in Egypt ; and, comparing the figures themselves, there is often a striking resemblance ; in some instances, one could well imagine the Egyptian idea depicted by an Indian hand. These temples were cut out of the amygdaloidal trap by a pick ; the marks of the tools are still visible. The work was doubtless laborious, but required but little skill and no science.

The ancient Mahommedan rulers left us noble examples of architecture, elegance of design, massiveness, and science in construction. The Taj at Agra, and its very inferior copy at Aurungabad, are good examples of masonry. There are also some fine examples of stonework and scientific construction in the Mahommedan remains built by Yoosuf Khan in 1489, around the very ancient Hindoo city of Vijzapùra. They were also aware of the importance of canals, and commenced our present system in the north. Thus the history of native engineering in India as regards

the Hindoo is not brilliant, but it was useful. Yet we, with all our boasted science, have failed to do what the Hindoo did in a most efficient manner in many parts of the country (see a map of the Tondeman's country south of Tanjore; it is a network of tanks); that is, store water all over it. We have taken water by annicut in the large deltas, following the example set us by the natives; but in storing water against an insufficient monsoon, we have done scarcely anything; yet this is the great want of India to protect her from those dire famines, when the dead may be reckoned by tens of thousands.* The matter is, however, I acknowledge, one of difficulty. The ancient Hindoo was fully alive to the necessity of storing water, more so than we are—being only birds of passage; and the necessity has not as yet penetrated the Government: the Hindoo had a power we do not possess; he turned out the whole of the inhabitants of a district, and made them make their own tanks by compulsory labour. We do not behave in this way; but the raising funds by local taxation and municipal officers would appear to be our remedy. This, the most important subject in Indian engineering, will be again referred to when I come to discuss the proposed engineering department.

Since our advent in India, during the first years of fighting and turmoil, the irrigation works in India were doubtless much neglected; and to those troublesome and changeable times is due, in some measure, the destruction of many noble tanks in the south. The destruction of the tanks in Central India, and to the east, must be attributed to a much earlier period.† When the attention of our rulers was first turned to Public Works in India, we naturally, and, indeed, of necessity, used the means we found in operation, placing the chief authority in the hands of the district European officer. This system was probably much the same as we find detailed in the Report of the Commission on the Public Works Department, ordered to assemble

* In the Guntoor famine, 1837, 200,000 people were said to have perished, and, much later, one million in Orissa.

† Tanks of very large size, in the great jungle tracks of Orissa, will probably date 400 B.C.

March 1851. This Committee was composed of Y. D. Bourdillon, Esq., Collector of Northern Division of Arcot; Major F. C. Cotton, R.E., Civil Engineer Seventh Division; Major G. Balfour, R.A., Member of Military Board. These gentlemen, with much industry and a most praiseworthy independence, formed a plan for an extensive and comprehensive enlargement of the Department, and one in some measure better calculated to cope with the wants of the country, and to insure a better and more economical method of carrying out works.

Referring to this Report (Parliamentary Papers, 407, I), we find that generally, amidst most praiseworthy exertion on the part of the engineers' officers, there was great laxity in the accounts, a totally insufficient number of officers, a lamentable misapprehension of the magnitude of the work before them, and an entire want of appreciation of the best way of using the energetic and valuable services of the military engineers at their disposal. Captain Best and all officers were tied down by a centralisation that cramped their efforts sadly—a centralisation that has, I fear, grown upon us.

The works of the Department were then carried on under three distinct and independent departments, viz. :
1. The Public Works Department of the Board of Revenue;
2. The Superintendent of Roads; 3. The Military Board.

The Board of Revenue had the control of all irrigation works, all civil buildings in the provinces, and all roads and bridges not included in the "Trunk Roads" or in military cantonments, and all canals, etc.

The Superintendent of Roads had the sole superintendence of the great lines of communication which had been classed under the term "Trunk Roads"; he proposed all new roads on these lines, as well as all repairs and improvements; and he and his subordinates executed the greater part of the work.

The Military Board had the superintendence of the construction and repair of fortifications; of all public buildings, both military and civil, at the Presidency; the Government roads and all bridges at the Presidency; all military buildings and forts in the provinces; and roads

and bridges, etc., in military cantonments, as well as all roads, bridges, and civil buildings and works in the Sangor Division, etc.

At this period, viz., in 1851, this system was found utterly insufficient. The Committee above-mentioned—with reference to the Board of Revenue—say, at paragraph 22, page 8, of their Report :—

“ But though we are of opinion that the Board have to this extent acquitted themselves of the duties committed to them, we are of opinion that they have much come short of what ought to have been done in more important parts of their duty, viz., in the higher functions of a general controlling authority. We find an absence of anything like a general view of the resources and of the wants of the different parts of the country. With one imperfect exception, there has been no attempt to ascertain the number, size, or condition of the works of irrigation throughout the country ; there seems to have been no comparison of one district with another, either as to the quantity of work done, the cost of doing it, and its results ; no inquiries as to capabilities of districts for improvement or as to the backwardness of some officers to bring forward improvements, compared with the multiplicity of such recommendations received from others. And as to the roads, there has been no comprehensive view of the wants of each district, no general scheme of roads proposed, no consideration of the sort of road or other means of communication most proper to each locality, etc.”

And so for the other departments ; they were found inadequate and unsuited to the wants of the country. The officers were far too few, the means at their disposal ludicrously inadequate to the extent of the country, and the system of control too extended, and, consequently, too loose, to be of any value.

The duties of the Native Executive must have been sufficiently onerous without his judicial and other duties. At page 20 we read :—

“ A Tasildar's division, or Talook, ranges generally from 350 to 600 square miles ; contains from 100 to 300 villages, with from 200 to 300 works of irrigation, and yields a revenue of from one lac to two and a half lacs of rupees (£10,000 to £25,000). He has a treasury and an establishment of servants, some for accounts and correspondence, others stationed out in the Talook in charge of subdivisions of it, etc. Almost all the powers which a collector exercises, fiscal, police, judicial, and miscellaneous,

are confided, in a minor degree, and within the range of his more limited jurisdiction, to the Tasildar, who may be described as the Collector's Deputy within his Talook."

This man had, however, entire control of the executive of all works in his district. As may be supposed, the control was small; and, with reference to the accounts at page 22, we find the opinion recorded :—

"The opinions of the Collectors vary as to the degree of credit due to these daily accounts: some think they are generally authentic; but the majority express the opinion, that they are not very faithful or exactly kept, and the civil engineers express the same conviction still more strongly."

We have also evidence of the want of good foremen—called maistries in India—a want still much felt; in fact, one of the greatest wants of the Department. At page 28, paragraph 80, we read :—

"The utter ignorance and inefficiency of the present class of maistries have long been notorious to every officer brought into contact with them; and they have repeatedly been brought to the notice of higher authorities."

And even to this day, this is one great want in the Department, and one of the greatest moment in carrying out any works to a satisfactory conclusion. My plan is the only one that can fully meet this difficulty. You want men acquainted with the language; you want men accustomed to the climate, and skilled in the native method of work: at the same time conversant with the best practical methods. Such qualifications you cannot find ready to hand in Europe, nor has experience proved its advisability. Europeans too often take to drink, or otherwise misbehave themselves. The system I propose will provide for the proper training of foremen, European and native.

My own experience of the Department commenced in 1853-54, when, after some time employed on the Madras Railway, and especial duties under Lord Harris, Governor of Madras, I was ordered to take charge of certain works out of the hands of the Civil Authorities, in order that they might be carried out by the new department. The insight that I then obtained into the working of the old system was sufficient to prove, as far

as my observation went, that the work done was extremely expensive and carried out in a very inefficient manner, even where the original plan had been good. The difficulties I had to contend with were very characteristic of the native customs.

The work I had to take over was a canal, a great part of which had been excavated. These excavations had been done entirely by Wuddas, a distinct race, who dig wells and live by digging. These men had always been paid by natives ; and, as I subsequently learnt, were mulcted by all. The Tasildar, or head of District ; Karkoons, or accountants ; peons, or policemen : all got their fees from the price of their labour. On my taking charge, I paid the head men of the tribes personally, and made them understand that they were not bound to pay to anyone any fee.

After some months, these head men came to me, and said that they had been summoned before a court to answer a charge of theft from a grain field. This charge, I found, was instituted by the peons or policemen who were formerly in charge of the work. I told these men to go to the court and say nothing. After the court had met I went down, and requested the native magistrate to allow the witnesses for the prosecution to be brought in separately, and the remainder to be kept apart.

I cross-examined these men (four of them). They could not agree whether it was moonlight or not ; whether they seized the men before they stole the grain or after ; and not one of them, when called upon to swear that the men in custody were absolutely the men (for, at the time, the peons said the men had escaped), would swear to their identity. It was, in fact, as the head men of the tribes had informed me, simply a case trumped up, because they refused to pay the usual *douceur*, on receipt of the price of their labour. It is as well that this native system of feeing should be known ; for it has been, and is, the foundation of much peculation, and the cause of much of the high rates in the Public Works Department.

I believe, however, it is a system that has been gradually and surely decreasing since the year I write about,

1853. Then it was well known that every native contractor, and even often every labourer, was supposed and expected to give *dustorree*, or custom, to every native supervisor or accountant, in the shape of a small percentage on his pay. The high character and irreproachable and unapproachable honesty of the Engineer officers have always acted as a means of repression of this custom, but it is still far too prevalent in the lower ranks of the Department.

There is, in the Report on the Public Works Department in 1851, a very instructive and important paper, by, then, Captain A. Cotton, now Sir A. Cotton—by far the most independent, energetic, and competent officer that the Department has ever produced. It is curious to compare the statement there made, written in 1837, with the actual state and wants of the Department in 1873.

Paragraph 61, page 312 :—

“The following is a summary of my views on this subject :

“1st. That the nature and importance of the subjects of the irrigation and communications have been hitherto altogether misapprehended, leading to a loss of revenue, and a retardation of the progress of improvement in the state of the community, which is quite beyond calculation.

“2nd. That, as respects communications, no country whatever can prosper if they are not made the very first objects of attention ; and that, as respects irrigation, it is in this country owing to the peculiar character of the climate, undoubtedly the very first subject to be attended to ; inasmuch as we cannot rationally expect that there will not be a famine and want of every kind, just in proportion as the cultivation is more or less dependent upon local rains without the help of artificial works.

“3rd. That the expenditure on the irrigation has certainly not exceeded one-third of what, on the strictest principles of economy, it ought to have been ; and that from the little consideration that the subject of communication has been thought worthy of, there has been in most cases nothing at all expended ; and in others, as in the Hyderabad and Masulipatam road, and in that from Madras to Poonamallee, the most expensive and unaccountable expenditure, totally disproportioned to the advantages to be attained and to the real necessities of the case. The former cost at the rate of 10,000 Rs. a mile, the latter 50,000 Rs. Most of the other great lines of road in the Presidency are literally at this moment impassable, at times, for want of a few bridges and

trifling works, that would not cost more than 200 Rs. per mile ; and some other lines, on which bridges were built, are now, and have been for many years, totally impassable for want of repairs that would not exceed 20 Rs. per mile per annum. These things could not possibly have happened had the subject been viewed as it really is, one of the very first subjects to be attended to.

"4th. That when once a country is favoured, as this is, with a strong and upright Government, **the only things which can possibly support effectually internal arts and manufactures and foreign trade, are an abundant, certain and cheap supply of food, and rapid, easy, and cheap transport* ; nor without these can a nation make rapid progress in knowledge. While a people are scarcely provided with food, and not at all with clothing, they cannot be expected to think much of other things ; and while intercourse is so restricted the state of a community approaches to that of men in a prison, each one shut up in a separate cell ; so that the progress of the individuals depends wholly on the discoveries of their own mind, instead of having also the full benefits of all the thoughts of the other inmates of the place ; whereas, just in proportion as the freedom of intercourse approaches to completeness, the state of each individual approaches to the state of a person possessed in himself of all the powers and capacities of the multitudes of minds of which that community is composed.

"5th. With respect to what should be done in our present circumstances, that such a systematic arrangement should be made for the conducting of Public Works, as would secure these branches of the management of the country one of the first places among the subjects which require the attention of Government, either by the establishment of a separate office or Board of Public Works on a liberal footing, or by such other arrangements as may appear necessary.

"6th. That every officer of engineers, whose present occupation can possibly be taken up by others, be immediately made available for this department.

"7th. *That the department be thrown open to every person, whether in the service or not, who can fit himself for it.*

"8th. That at least double the present expenditure should at once be allowed for the irrigation, besides very large sums for the communications.

"9th. *That capital should be obtained on loan*, and that on no account should any money be paid out of the Treasury for improvements. Capital paid from the Treasury costs the community perhaps double its actual amount, taking into consideration the expense, etc., of collecting, the cramping of private enterprise by the diminution of the funds of individuals, etc., while capital obtained on loan costs absolutely nothing. If ten rupees are

* The italics are mine.

taken from a man as a tax, it is sheer loss to him, and it must often happen that it is taken when he has an opportunity of laying it out to great advantage; if it is taken on loan, and laid out in a way that will yield both public advantage and actual returns in money besides more than sufficient to pay the lender his interest, no individual loses anything, but the community gains.

“And for such works as bridges upon which it is not advisable to levy tolls, how much better is it that the interest of their cost should form a permanent moderate charge upon the community, than that the cost itself should be paid at once. In the latter case the present moment must be heavily taxed to obtain an advantage, which will only be realised in a course of years; in the former, the advantage is only paid for as it is actually possessed. In the latter case, works may be at once undertaken to a prodigious extent, and the country greatly improved without delay; in the former, only a small extent of work can be undertaken at first, and the community must wait many years for others equally necessary.

“10th. That various details of internal management, now wholly omitted, are indispensably necessary to keep the department in any kind of order, and prevent the recurrence of such mistakes as I have endeavoured to show have hitherto been committed in it; such arrangements as these, for instance: Annual Reports on the state of irrigation, both from the Civil Engineers and Collectors; a General Annual Report from the Board of Revenue; rewards and penalties to secure every person in the Department obtaining a competent knowledge of the language of the Division; examination of officers, etc., and other details, which in almost all organised departments are considered necessary to ensure their efficiency, but of which this has hitherto been thought quite unworthy.”

This was written in 1837. Since then we have done much. We have struggled on; we have changed much; we have made many miles of railway, and have considerably increased the engineering establishment.

I would, however, point out that we have not, by any means, grasped the magnitude of the work to be done, nor the vastness of the interests at stake; nor have we yet become alive to the radical errors of our system. Considering the vastness of the country, the immense sums required, and the immense number of qualified men that the works would demand, it may have been, perhaps, impossible to have moved faster than we have done. But surely the following conditions of the Public Works De-

partment in India must be now patent to all, viz. : That, notwithstanding the checks and counter-checks, *WORK is unsatisfactory in the HIGHEST DEGREE* ; that true *responsibility is nil* ; that the resources of the country are *by no means adequately used or developed* ; that native talent is *altogether IGNORED* ; and, finally, that the time has arrived for a thorough reformation of the Department commensurate with the just demands of the country and our duty towards it.

The Committee of 1851 proposed extension of the Engineers' Corps, and certain reforms in their training and in that of their subordinates. These have proved insufficient. Whether they were the wisest that could have been taken at that time, we need not discuss here. I would, however, observe, that I differ, under the present circumstances, from the members of that Committee, in considering that superintendence is chiefly wanted, and not responsibility (paragraph 104). We want practical knowledge and direct responsibility. What is the present system ? Let us briefly describe it.

There is a Chief Engineer of a district or country ; Superintending Engineers, according to extent of the same ; Executive Engineers in charge of Divisions, with assistants under them ; Overseers, Storekeepers, etc., and an entirely separate Account Department.

The Chief Engineer resides generally at the chief town, with the Chief Commissioner or Resident. He *sometimes* goes on a tour of inspection. The Superintending Engineers correspond with the Executive Engineers of their circle, decide upon plans, estimates, etc., etc., or refer them to the Chief Engineer. The Executive Engineer has charge of all works of all descriptions within his division, roads, buildings (civil and military), irrigation works, tanks, etc., etc. He has to correspond and refer matters to the Superintending Engineer and the Accountant's office. The Superintendent Engineer has to see and revise every plan, estimate, and survey (and he is often totally incapable of doing so), and give any directions he chooses about carrying out works sometimes one hundred miles or two hundred miles away. All accounts have to

be sent in monthly by the Executive Engineer—a figured abstract for each work, detailing labour, materials, etc. (see form X, Appendix). The papers also required were very numerous.

1. Copy of Cash Book.
2. Statement of Cash.
3. General Abstracts of Labour.
4. General Abstracts of Material.
5. Salaries.

Forty or Fifty Figured Abstracts.

These have to be compiled from his subordinate's figured abstracts. It is the minutiae into which these figured abstracts enter that I object to. The results of the system are now before the public, where I may leave them. These minutiae are no good to the Executive Engineer, because his district is too large, distances too great, and his duties too numerous and too onerous to enable him to check them on the spot; they are still more useless to Government—they are *on paper*. You strive after a *sweetly accurate system on paper*; in the meantime, after years of building, accounts, and supervision, your buildings fall down.

In the transitory state that we were then in, it was perhaps not altogether unavoidable; but these things are passing away. It is time, I say, that a new system—a vigorous system, an honest system—should replace the old effete one. Surely our rulers have proof enough in useless buildings and in hundreds of lacs wasted, to satisfy any Government that reform, and a thorough reform, is necessary. Let us not, then, look back on men who, thrust forward by interest and good fortune, found themselves in posts unfitted for them; but rather let us take heed that our duty, and our duty *only*, is done to our sacred trust of the development of the intellectual and material resources of India. No profession in the world calls more upon the highest intellectual resources than engineering; but the highest intellectual qualifications—and you *have plenty of them in the Department*—are useless, unless you combine the practical knowledge of putting a few stones together, etc. That is the simple

reason the Sangor Barracks failed ; that is why the Kanhari Bridge failed ; that is why the buildings at Allahabad failed. Our rulers are, I maintain, in some measure alive to the fact that works of irrigation are wanted, but they fear to undertake them with the present Department.

A Department that shall elevate its superior officers above the classification of petty detail and squabbling over different rates of material, and shall have a class of executive officers who shall not shun or fear responsibility, might hope to gain a greater insight into the wants of the country. The Superintending Engineer having little or no responsibility in actual construction, could devote much time to the study of the development of his circle. At present, there is no life in the Department, because it is not really an Engineering Department ; it is an *olla podrida*—neither fish, flesh, nor fowl. There are Military Engineers with more or less practical knowledge ; Civil Engineers who do not find themselves on the same footing as their military brethren, but on a lower platform ; and a host of officers who have got into the Department, some by merit, but chiefly by patronage and interest, but all birds of passage, who have no stake in the country : who do not care twopence whether India's plains lie scorching for centuries, or her life blood—the waters of her rivers—rush in destructive floods into the sea. It is nothing to them as long as they draw their pay. Are there no native gentlemen that could be found to qualify themselves and take an interest in their country's weal ? Surely there are many such should the opportunity be afforded them. These men we must have. Our area of operations is so vast, the difficulty of obtaining men qualified by engineering and linguistic knowledge in sufficient numbers so great, that men are now called upon to take up every branch of engineering, who should not be entrusted with one, and this over areas that would employ twenty good men, if the resources of the country were properly developed and her wants supplied. We must have a real Engineering Department—a system that shall be acknowledged as a *Civil Engineering Department*, in which men shall be Civil Engineers who are able to bear

responsibility; an elastic system that can be indefinitely extended to grasp the wants of the country as they expand; a system that can be controlled and be kept in a healthy condition by extolling the worthy and eradicating the weeds. This can only be done by calling in the aid of the natives. I say that our present Department is a farce; and more—I say that all those in authority in India know that it is so; if they do not, they have had enough before their eyes lately to convince the dullest.

The past history of the Department points unmistakably to the fact that a number of highly paid Chief Engineers and Superintending Engineers do not protect the taxpayers from most disastrous losses. It also proves that the most elaborate system of accounts does not prevent speculation in the remotest degree. It is therefore not by a number of highly paid officials that we are to hope for a more useful and economical Department; that desideratum must be gained by infusing a practical knowledge throughout the Department, and placing the responsibility definitely and surely on one head; and last, not least, by simplifying the system of accounts.

To commence a review of the system that I propose, I will state, first, the training that the young engineer should undergo, and then follow him up, until I build up the whole system as I would suggest it. Before doing so, I would preface it by repeating and laying down certain broad principles that I consider our rulers are bound to observe in dealing with India. First, I would observe that the establishment of any Engineering Department should have for its object not merely the development of the resources of India, but it should also equally and primarily aim at the development and advancement of the intellectual and practical knowledge of the natives, and teach them not only to work, but to design. Secondly, that any Engineering Establishment must be the most economical and simple that can be devised, and not made with a view of finding high pay for a number of European officers, but made solely with a view to bring out the resources of India, intellectually and materially, in the quickest, least expensive, and most efficient manner. To

obtain this object, the following arrangements would be necessary. There should be Government colleges or schools at several large towns, say Poonah, Calcutta, Roorkee, Madras, and Hyderabad, or a less number should these be found too numerous. Here the native and European would have to pass a certain standard in mathematics, natural philosophy, etc.; and Europeans would have to pass in one of the native languages. The instruction would be in English. In several of the towns mentioned above, there is an embryo of such institutions. Men, however, who had gone through the same course in England, could pass the required examination in England, and then go through the second practical course (now to be mentioned) also in England, but would have to pass the prescribed examination at the Indian practical school after a sojourn of six months or a year, and passing in one of the native languages. These men, having already acquired practical knowledge in England, would receive some small pay, as probationers, during this time of service. This second practical stage has to be created; and this it is that I would lay the greatest stress on. Practical schools of instruction must be established. After a lad has passed out of the initiatory theoretical school, he should be sent to an iron manufactory and engine shop, or should be sent to some large works in progress, where he would find Government instructors to teach him the higher branches of his profession, and where he should pass through a practical training in masonry, bricklaying, carpentry, etc., or acquire a certain knowledge of iron-work and machinery.

The practical schools would be established for the time being at any extensive work or works where there were workshops. The student would there find a Government instructor in each branch. For fitters and moulders, and for the study of the different branches of working iron, there would be provided permanent instruction in the iron manufactories, etc., that I propose to establish. It might also be found convenient to establish a manufactory or manufactories for doors and windows and wood-work generally, where wood could be easily procured;

and thus save much expense in haulage of raw material. But for foundations, for bridges, for masonry generally, railway work, plate-laying, etc., the student would be placed under some Government official on some work in progress, whose duty it would be to see that the pupils under his charge worked practically and also acquired the knowledge demanded of them.

And here I would point out that India is the proper field for the student of the Indian Public Works. There are peculiarities in many things that do not strike the theoretical man. The iron ores are different. The iron ores found in England are chiefly argillaceous or calcareous iron ores, or hæmatite. The chief iron ores of India are nearly pure magnetic iron or oxides of iron, such as the Ahtoor Valley, that supplies Portonovo, and the iron ores of Woon and Mahtoor: these are particularly difficult to smelt, and, unless a suitable flux be found, the furnaces are sure to get *gobbed*, as the term is (*i. e.*, the iron forms into a viscous mass, and chokes the furnaces). Then, again, how different are the woods. The Indian woods are generally heavier and harder: some are very apt to split, and some liable to warp badly. They require to be understood. I consider the promotion of iron manufactories, together with mills for rolling bars, plates, and rails, the one great duty in the formation of any new, or remodelling of the present, Public Works Department. Doubtless, it would be expensive and uphill work at starting; but it is, without doubt, the duty of our Government to initiate such undertakings, and, should Government once establish such works, there would be no difficulty in selling them, when once fairly in working order. But such establishments would far more than pay for themselves in the development of the country. Such works stimulate progress in ever-increasing ratio. The use of machinery for excavations and embankments, for pumping, for haulage and manufactories, accelerates and cheapens work, so that much more can be done in a shorter time for less money: and thus money is made, and the wants and requirements of the people are increased.

The sites for such works would require careful con-

sideration. That such sites could be selected, there can be no doubt. The discovery of coal has removed the great obstacle. In the Ahtoor Valley, near Salem, there is an inexhaustible supply of iron; but I am not aware that coal has been found there. In Woon, iron and coal have been found, and the connection with the railway would not be difficult, nor with the Godavery river by the Wurda. In the course of this work I have again to refer to this matter.

Then, again, how different is the aspect of nature in India. Vast level plains, as in Hyderabad, Berar, or Nagpoor, of black soil; or in Raipoor, of laterite and black cotton soil alternately; the latter impassable in the rains, and every mullah an unfathomable pit. Who that has travelled over these plains at such a time has not longed for a railway, or at least a tramway; more particularly, too, in the hot weather, should he meet a string of three hundred or four hundred bandies or native carts, smothering everything in dust, and too often bearing in their track the dreaded cholera.

What a study for an engineer is the river system of India—rivers almost dry in the hot weather, and in the rains rising perhaps sixty feet in one night, and pouring forth floods such as are seldom seen in other lands.

A stranger, looking down for the first time into the bed of one of the large Indian rivers, laid out in melon beds during the hot weather, could hardly picture to himself the same river boiling down in the height of the monsoon. I say that hitherto these matters have not received proper study.* Engineers for India should be brought up amongst her native scenes, and taught to comprehend her difficulties and her power. Then, again, look at the mountain ranges. The Annamullay, Sher-varoy, and Neilgherry hills in the south; the Ramund-roog and Satpoora range, in Central India, with the Western Ghat, and the giant Himalayas in the north, afford a fine study for the engineer, and require his skill in laying out good roads over them, and developing their mineral resources and utilising their water power.

* The many accidents to Railway Bridges in late years will illustrate this. (See *Parliamentary Papers*, c. 643, p. 4, paragraph 7.)

The irrigation system of India is peculiar, and varies considerably, not only from the peculiarities of climate, but also from the varied conditions of soil and contours of the country. And this department in particular requires, above all, a class of native-trained officers, not only for the construction of new tanks, but for the conservation of the present extensive tank system.

Sir Arthur Cotton, than whom no one more deserves the gratitude of the people of India, seized upon the deltas of the large rivers and made the most of them. He also never ceased to bring to the notice of Indian officials the necessity of storing water. The original idea of the annicut or bank or wall across a river, is, nevertheless, an entirely native idea; and so are tanks or the storage of water. Col. Sir A. Cotton improved upon them, and added thousands to our revenues; but still, I say, we require a system to be established on this very point. As the natives did, we did. We made annicuts on the low plains and took off channels for irrigation; but we should treat each large river and its affluents on a system. Take the Paimunga, or the Mahanuddy during the monsoon (peculiar to India), when I have known three inches of rain to fall in six hours, they are most dangerous; and are the sources of dire loss to animal and human life. These might be controlled.

If we examine the rivers at present in hand, such as the Coleroon and Kistna and Godavery, we find the works are at a distance from the hills, and are in very extensive alluvial plains, where, on account of the gradients, the floods are not so excessive or so quick; but take the Paimunga or any large river, where it passes through a country with hills adjacent on either side, and the streams flowing into it at right angles down a steep gradient: in such rivers the floods are sudden and most destructive. The Poorna, flowing through Berar, and fed by streams at right angles to its course—from the north, from the Chikuldah hills between 3000 and 4000 feet high; and from the south, from low hills, has risen sixty feet in one night. Much, I say, might be done with these rivers, and much good land brought into cultivation by

commencing the deviation of water from the affluents and main channels nearer their sources into tanks and large reservoirs; or if no suitable sites for such should present themselves, channels for irrigation could be led off.

Thus the power and aspects of nature in India are different, and require study. At the same time it cannot be denied that the student in India would lose much by not being conversant with the numerous engineering works of Europe, and studying there the perfect application of labour to manufactories. But this last it is I would create for him eventually in India. You have coal. You have iron. You have skilful hands; it only requires a beginning, and, as matters now stand, I believe that Government only can successfully commence such works. But it is in India that the European student, the workman, and the engineer must learn to train the native to his future work in his own land. There will be some difference between the European and native workmen at first. The native will fail in large and heavy work, and excel, where delicate manipulation is required, as a general rule. But India's sons are quite capable of any labour, if only taught and trained, and it is our *duty* thus to train them. After receiving their training in India, it might be made the reward of scholarship that the first and most successful native scholars should pass two years in Europe for the study of important engineering works.

Let us go back to the engineering course. We have now the pupil in the initiatory school, the student and apprentice at his practical work, learning the routine of an engineer's office, and the general supervision and measurements of work, management of workpeople, and the chief practical parts and details of his profession, before he becomes able to fly alone. After passing his term in the practical school—say two years, it could not well be less, for building, and five years for a fitter—he could pass into some executive engineer's office, as an assistant, after passing his examination, either as a mechanical engineer or architect or hydraulic engineer. He would now be brought, on the strength of the Department, as a paid member. Until the native pupils could vie with their European

brethren in practical knowledge and efficiency, they would find posts in subordinate ranks as assistant executive engineers, as assistant accountants on works, or assistant overseers over repairs, or be placed in charge of stores. The assistant engineer would be promoted entirely by merit, and would be placed at such work as he showed the greatest aptitude for. These men would eventually form the body of Executive Engineers. From these would be chosen the Superintending Engineers and Chief Engineer. These are the officers of the Department, Public Works, and their training.

The Department over which these officers should have control would require to be entirely remodelled. At present, a man is too often called on to perform that which is physically impossible, and to apply himself to too many branches of his profession. This is neither fair nor advantageous to the Departmental officers nor to the taxpayer.

The Department would therefore be divided into four grand Divisions, to each of which there would be a Chief Engineer and Council : composed of the Chief Engineer ; two Superintending Engineers of same grand Division ; and two Civil Officers, or Commissioners of the District. The Grand Divisions would be—

1. Military Buildings, etc.
2. Communications, Roads, and Civil Buildings.
3. Railways.
4. Irrigation.

List of Officers of the Public Works Department for each Grand Division :—

One Chief Engineer and Secretary to Government Military Grand Division.

One Chief Engineer and Secretary to Government Roads and Civil Buildings.

One Chief Engineer and Secretary to Government Railway.

One Chief Engineer and Secretary to Government Irrigation.

Superintending Engineers for each Grand Division, as may be required.

Executive Engineers, four classes, as now, for each Grand Division, as may be required.

Assistant Engineers, two classes.

Overseers, two classes.

Store-keepers, two classes.

I will now proceed to describe the duties of the different Grand Divisions, then of the several officers, etc.; and afterwards give a general sketch of the accounts that would be required from each.

The Military Grand Division would be conducted and supervised entirely by Military Engineers. No theoretical examination would, of course, be necessary; but every young officer entering the service in India should pass two years in the practical school, either in masonry, etc., or in machinery. The military cantonments, and all roads and buildings therein, would be exclusively in the charge of military men; and all buildings and roads within a certain radius, without cantonments, as might be thought necessary for military purposes; arsenals, forts, gunpowder manufactories, and all manufactories of warlike stores, would be under their exclusive control.

The three next grand Divisions are in the order of their respective importance, the least important first.

Communications and Civil Buildings. This grand Division would comprise all roads not included in the Military Division, or those that would be classed as local or secondary roads, and which it is proposed should be paid for from local or municipal funds, and be under the control of a Municipal Board. All main roads from civil stations, and to the limits of military cantonments, would be classed under this head; also all civil buildings and works not in a military cantonment.

The third grand Division—Railways—would be a most extensive Division, and would embrace civil and mechanical engineering. This Division would also undertake tramways; and engines, machinery, and plant for railways; and all stores and buildings, etc., for the same, would come under this head.

The fourth grand Division—Irrigation—is the most important, as well as it is generally considered the highest

branch of the profession. As in India it is without doubt the most important, the most able and active men would be selected for this work. All tanks, irrigation channels, annicuts, sluices, etc., would be under their control.

A fifth and also a sixth grand Division might suggest themselves—one for Coasts and Harbours, and another for Workshops and Ironworks; but sufficient has been said to develop the general plan.

Now it is by no means necessary, nor would it be expedient, that the boundaries of the different executive Divisions under the different grand Divisions should coincide. They would not. For instance, a Military Executive Division might answer to a district or country, as Bengal, Oude, or Nagpoor, where there were sufficient military buildings to constitute a charge; the same country might include several executive Divisions under the second grand Division; but the Railway Executive Division would be designated by a particular line, as Punjab and Scinde Railway, or Nagpoor and Oomrawuttee Railway, and would pass, perhaps, through several districts or countries. The Executive Division of the fourth grand Division would sometimes comprise a country or district where there are many tanks and no channels; but where the executive Divisions consisted of a river, its affluents, and its irrigation channels, the circle would comprise the whole course of such river, and it would be divided into two or ten executive Divisions, according to its length and its importance.

A Superintending Engineer would have charge over several executive Divisions, and these would form a Superintendent's circle.

I would here remark that, though I lay down a scheme for a Governmental Department, yet I would not be supposed to advocate such an arrangement altogether. Considering, however, the present state of India and her mismanaged Public Works; the almost total want of iron manufactories, in all its various branches; and also the want of a large and appreciative body of native capitalists, who would combine for any large scheme either of irrigation or communication; the work as pointed out must be

done by Government. As I have said before, the welfare of India and its inhabitants must form the foreground of any Public Works Department; and it must never be lost sight of, that it will ever be for the true interest of Government to induce native governments to undertake remunerative works of irrigation and communication, and also to induce wealthy natives to form companies for the carrying out of such works, in order that Government may be relieved of the continual maintenance of an expensive establishment of officers and labourers. In the case of native rulers, they would employ their own engineers; in the case of a company, it also would employ its own engineer; it would, however, be necessary that a Government engineer should see that the work was carried on agreeably to specification and plan, etc. In the one case, a native government may be considered as a company carrying out its own work; in the other, the company would be contractors working for the Government. This seems unavoidable, as Government claim all land, and taxes are chiefly derivable therefrom. In the case of irrigation works, Government might take over the works when completed at a fixed rate, or accept a certain sum per acre from the area irrigated. The price of water may safely be left to the general law of supply and demand.

This most desirable object of inducing native States to undertake important works, and native gentlemen to form joint stock companies, can never, in my opinion, be properly attained unless we train native gentlemen in engineering, not only in the lower, but the highest branches, and thus enable them to become the architects of the fortunes of their own country. It would be found that native States would more readily employ native engineers than European; in fact, until such men can be educated and made generally available, no extensive system of engineering works will be spontaneously introduced by native chiefs.

In the Report on the Public Works in India, evidence of the usefulness of employing natives is prominent. It was, however, in very subordinate positions. Now the time has arrived when the highest positions in the De-

partment should be obtainable by duly qualified natives. I do not say that at the present moment there are natives qualified to take a leading position ; but let Government unshrinkingly do their duty ; let it be known that the higher positions in all departments are open to duly qualified native gentry, and it will not be long before you have men fully qualified to fill them. At all events, we should not only offer such positions to their ambition and talents, but should provide them with the means of obtaining them. And this, I would observe, cannot be done, not fairly be done, by insisting on their proceeding to England, where the expense, climate, and mode of life are so strongly against them. Major Evans Bell, who has studied the subject of India and her races and government, and whose views are daily gaining ground, observes at page 64 of *Our Great Vassal Empire* :—

“Local work can be better done by natives than by Englishmen. Native talent can never be so well selected or so well applied to the work of local administration by the British Government as in a Native State.”

And at page 62 of the same book, we read, after some remarks on General Sir Mark Cubbon :—

“There are now about thirty English gentlemen in Mysore employed on very simple work in that Department on very handsome salaries, where two or three at the most would really be required, if any pains were taken to train Native Engineers or even any encouragement offered for them to come forward.”

As a temporary measure until the new system should come into play, the remodelling of the Department should be thus conducted. Government should pick out four of their best men as Chief Engineers over the four grand Divisions (that is, twelve for all India, four for each Presidency), and place Superintending Engineers over circles of executive Divisions, under the different grand Divisions, according to their qualifications ; and Executive Engineers to Divisions of such a size that they can properly carry on their duties.

There are many highly educated and clever officers who, although perhaps insufficiently acquainted with actual practical work, are fully able to appreciate and plan im-

portant works of irrigation and communication. It would have been better had every man in the Department gone through a regular practical apprenticeship ; but the present Government can only start with the material in hand ; and as it would be impracticable at once to obtain thoroughly practical knowledge with extensive Indian experience, Government must use their Indian experienced officers as Superintending Engineers, and select the most tried and practical men for executive charges. It is presumed that men knowing the responsibility will not accept such positions unless duly qualified.

Cooper's Hill can never furnish these men. You do not want book learning. All experience, and, last, and most emphatically, the Saugor Barracks (besides a host of others), declare this. The Executive Engineer had evidently no practical acquaintance with masonry, and it is presumable that the Superintending Engineer had not either ; for if they had, how could the work have gone on as it did for so many years ? The Chief Engineer doubtless culled the choicest specification for rubble masonry from the best Civil Engineering or Builder's guide. *Cui bono* ? There was no practical element to profit by it.

How is this practical element to be obtained for the Department with the least delay ? Take any young men who have served say two or three years in an engineer's office or college in England ; let them be examined in mathematics and theoretical knowledge ; and then apprentice them to an executive engineer in India who is known as a practical man. These men might receive some small pay for their services as probationers, until they had passed the Indian examination, when they would be brought on the strength of the Department. This system would do until the new system should fill up the ranks.

To recapitulate the general arrangements and ideas on which it is based, the method that I would advocate as a permanent Engineering Establishment should have its foundation and home in India. It is the undoubted duty of our Government, first, to develop the resources of the country ; and, at the same time that they do that, they can best develop the intellectual resources of the

natives. Secondly, Government is bound to see that the taxpayer is protected, and that the resources of the country are not wasted. To obtain that, fix the responsibility firmly and undoubtedly on the executive agent; and have Superintending Engineers whose duty shall be to develop every resource, not squabble over petty rates, or meddle with every petty detail. Now an Executive Engineer should be solely responsible for his work; but he must not be interfered with. If Captain Faber, of the Saugor Barracks, had been made solely responsible for his work, and had no one to tell him what, in his opinion, was good rubble or otherwise, he was justly punished. But here is a Colonel of Royal Engineers—inspects, sees nothing. Superintendent of Royal Engineers makes no sign. Colonel Maxwell, Chief Engineer, writes a Minute on Rubble Masonry. I have no doubt Colonel Maxwell might select an excellent specification for rubble masonry from many works; but it would depend on the workmen and on the description of stone whether the work would be good. There is rubble masonry and *rubble masonry*. In one part of a country, you will find that masons build capitally with schist or laminated stone; perhaps twenty or thirty miles off, the masons can only build with basalt; and the one can only make good work with the stone he is accustomed to. This is a case where practice can only teach, and where practical knowledge can only save a building. No specification on earth without practice could do it.

It has been over and over again shown that this check upon check answers no useful end; and this last case shows that even after all the Chief Engineers and Superintending Engineers, you have at last to come down on the Executive Engineer. Therefore, as the Executive Engineer has the real responsibility, and really, in fact, is in nowise protected by having highly paid Chief Engineers and highly paid Superintending Engineers supervising that which, if it turns out bad, they are not held answerable for—make him, the Executive Engineer, solely and truly responsible, and let it be known for once and for all that he is so. It is the first duty of the Government to the country and people of India that they procure efficient

and practical men as Executive Engineers. In my plan, the Executive Engineer is left entirely to his work. The Superintending Engineer is answerable for the general design; the Executive Engineer for the construction. The Executive Engineer is the engineer carrying out the work for the Government on certain pay, as for any company; the Superintending Engineer is the Government Engineer, answerable that the work is generally good, and according to plan and specification.

Let us now consider the separate duties of each officer, so that the responsibility may be duly placed.

EXECUTIVE ENGINEER.

The Executive Engineer should have a district of such size, that he can properly supervise it. No law can be laid down for this, as it must depend on the quantity of work to be done. (I have known a district to be sixteen thousand square miles, half the size of Ireland.) He would have to make all estimates, plans, etc., up to 5000 Rs., in his office, and would be answerable for all accounts, which would be sent in only quarterly. This would not hurry him. He would have plenty of time to go round the different works, and satisfy himself that the work was good, and measure the work and ascertain that it was enough for the outlay. The Executive Engineer should also have power to purchase material* when wanted, and when procurable at cheap rates; to collect stones, bricks, etc. Salaries would be paid monthly by the Executive Engineer; the vouchers, however, would only be sent in quarterly. The accounts of the Executive Engineer will be considered under that head.

At the end of the year the Executive Engineer will draw up a general report, showing progress of works, works completed, works remaining uncompleted, and the amount of supervision allotted to each work; his own salary and allowances being shown as a percentage on the amount of each estimate completed, or partially completed, during the year. It would, in a certain way, be a distinct

* In 1859, when about to commence large civil stations, I requested Government to allow me to purchase wood—which I could have done for 2 Rs. per foot. I was refused. When bought, it cost 5 Rs. 12 Ans.

record of activity or otherwise. The Executive Engineer would be held solely responsible for the stability and soundness of his work, and the quality of all material used by him, and also for the price of the same. The Superintending Engineer would in no wise exonerate him for bad work or material. The Superintending Engineer is only answerable for the general design of plan and construction.

The Executive Engineer, for all plans and estimates under 1000 Rs., would only send in one completion report, when the work should be finished; but the plans and estimates would require to be sanctioned by the Superintending Engineer within the limits of the Budget.

SUPERINTENDING ENGINEER.

The Superintending Engineer would have under his supervision several executive charges—under one of the Grand Divisions of Military Works, Roads, Railways, or Irrigation. For instance, let us take Roads; let the district be Nagpoor. There would be four executive charges, probably North, South, East, and West. There would also be a sufficient number of executive charges in Irrigation and Railways to employ each its Superintending Engineer. If the Railway were under Government, it would not be necessary, as shown above, that his circle should coincide with that of Irrigation or Roads, but would in this case extend probably from Nagpoor to Bombay, divided into four or five executive divisions. The Superintending Engineer would assist and advise the Executive Engineer in every possible way. He would cause all plans, etc., under 5000 Rs., to be made in the Executive Engineer's office, but for all estimates over 1000 Rs. he must satisfy himself that they are correct. All plans, etc., over 5000 Rs. would be made in the Superintending Engineer's office. He must see that all plans are fairly and duly carried out, according to specification, etc.; in fact, as I have said before, he might be considered as the Government Engineer, seeing that certain works were properly carried out, as by the Engineer of a Company; but a closer union would be between them, as both would belong to the same service. The Superin-

tending Engineer should also be considered as a Consulting Engineer, and be liable to be called in by Executive Engineers for his opinion and guidance in critical or emergent cases.

Much would depend on the relative understanding between the Superintending Engineer and the Executive Engineers under him. It would be advisable to provide against ill-feeling and personal animosity; it would be necessary, therefore, should the Superintending Engineer wish to dismiss any Executive Engineer for incompetency or neglect of duty, that he should report the matter to the Chief Engineer of the Grand Division of the delinquent, and the Chief Engineer and two Superintending Engineers of other circles should form a court of inquiry. For incompetency the punishment would be dismissal; but under the system as now proposed, it would not probably often occur. For minor offences, reduction to a lower rank of Executive Engineer, or removal to another Grand Division, as from Irrigation to Roads, etc., would be the penalty.

I need not enter into the duties of the Assistant Engineer; he will always, in the first instance, be subordinate to the Executive Engineer until he shall have been promoted to a separate charge.

OVERSEERS OR FOREMEN.

This post is the most important and the most difficult to fill satisfactorily. Men brought from England too often take to drink or evil courses, from being necessarily far removed from control, and the habits and tendency of the climate too often tend to demoralise them. Far be it from me to say that these faults are universal. I have known some clever and exceedingly worthy men, but they are few and far between; and I would generally prefer a well educated native, if he could be got, because he would be more useful in the climate and would not drink. These men would be especially trained by my system. After passing an examination of a lower standard in the theoretical school, they would pass into the practical school, where they would choose which line they wished to follow, and would be thoroughly instructed in

it. They would not be allowed to shift from one to the other ; but they would be obliged to acquire a thorough practical knowledge, and an efficient manipulation, before they would be allowed to take up another. This would particularly refer to the fitters, whose term of service could not, with any utility, be lessened under five years, and would be better left at seven. There would be also a large class of surveyors and draughtsmen, writers, accountants, etc. : these might all be trained at the same schools. I have not, however, entered into the subject of offices, establishments, etc. This would be easily arranged, should the Department be brought into an efficient working state.

THE COUNCIL.

One Chief Engineer.

Two Civil Servants.

Two Superintending Engineers.

The duties of the Council will be to consider any extensive scheme that may be brought before it connected with their Grand Division ; say, for example, for Irrigation. The Chief Engineer or Superintending Engineer of a Circle wishes an extensive system of works to be constructed along the course of a river. The matter will be referred by the Chief Engineer to the Council. The Chief Engineer will associate with himself two Civil Officers of the District through which the river flows, and also name two Superintending Engineers as his Council. They will take with them one or two Executive Engineers, as may be thought proper, to conduct the surveys, and having studied the ground and proposed scheme as a whole, will order the necessary surveys, etc., to be made, or reject the scheme, as may be advisable. If the scheme be approved of, the Council will order the surveys, levels, etc., to be made, with all necessary information ; when this is completed it will again behove the Council to consider the project in its more advanced state. When finally approved of, the Council would give the necessary orders for its commencement, when perfectly assured that all the money necessary for the undertaking is forthcoming. The Council will also be summoned to consider

any question of interior economy, or of accounts, or departmental discipline. The Council would also take into consideration the Budget, the amount necessary, and decide which works were the most urgently required, and would apportion the amounts to the different Engineering Circles.

DUTIES OF OFFICERS OF THE PUBLIC WORKS DEPARTMENT.

*Chief Engineer,** President of Council of his Grand Division, and Secretary in immediate relation with Government.

Superintending Engineers to supervise generally the executive districts under their charge; to make themselves thoroughly acquainted with every feature and resource of the country; to suggest and originate schemes for improvements, and make all plans and estimates for works over 5000 Rs.; to render every assistance and counsel to the Executive Engineers in carrying out their works speedily and economically; in fact, to act as Consulting Engineers to the Executive Engineers; to check by occasional visits, at odd times, Executive Engineers' measurements; and to see that accounts and stores are properly kept. Two will be chosen from each Grand Division as Members of Council.

Executive Engineers to make plans and estimates, under general directions of Superintending Engineer, for all works under 5000 Rs.; to be solely responsible for the quality and correctness of all work of whatever sort; to keep in constant check measurements of assistants and overseers; and to send in accounts and forms correctly.

Assistant Engineers to obey the orders of the Executive Engineer; when in charge of special work, to send in same papers as Executive Engineer.

Overseers to keep nominal rolls, and make constant measurements of work, materials, etc.

Store-keepers to keep accounts of all stores received and disbursed, and to take receipts for all stores given out.

* There would be four Chief Engineers for each Presidency, as there would be four Grand Divisions in each Presidency.

ACCOUNTS TO BE RENDERED BY THE DIFFERENT DEPARTMENTAL OFFICERS.

Rank.	Books kept in their own Offices.	Returns sent in Periodically.	Remarks.
STOREKEEPER.	Lists of all stores and their prices. Account of all receipts and disbursements. List of vouchers.	Half-yearly account of receipts and disbursements, Form E.	Books in office to be periodically examined by Executive Engineer, and stores checked and compared with store account. All stores placed at work will at once be charged against work in Ledger. The Executive Engineer, or his assistant, must personally check store account half-yearly.
OVERSEER.	Daily muster roll of labourers. Measurement of works. Cash Journal, Form D. Ledger for each work, Form H.	Monthly return of receipts and disbursements of Cash, F. Measurements of works in progress, Form G, ready for Executive Engineer when called upon.	Muster rolls must be kept by writer daily, and the people paid by these rolls, which must be kept in office as voucher. A muster roll for each work.
EXECUTIVE ENGINEER.	Cash Journal, Form D. Ledgers of works under own superintendence.	Quarterly receipts and disbursements, Form C. Completion report of works under 1000 Rs., Form A. Progress of works over 1000 Rs., Form B. Store account of Storekeeper checked and attested, Form E. General report.	

ACCOUNTS TO BE RENDERED BY THE DIFFERENT DEPARTMENTAL OFFICERS—continued.

Rank.	Books kept in their own Offices.	Returns sent in Periodically.	Remarks.
SUPERINTENDING ENGINEER.	Cash Journal of money paid to Executive Engineers. List of works under 1000 Rs. " 5000 Rs. " 10000 Rs. for each Executive Engineer. Division.	Return of sums drawn by Executive Engineer against Budget Allotments. List of works completed under 1000 Rs. List of works completed under 5000 Rs. List of works completed under 10000 Rs. List of same in progress. Report half-yearly.	
CHIEF ENGINEER.	Sums paid to Superintending Engineers. List of work of each Superintending Engineer's Circle, classified under 1000 Rs. " 5000 Rs. " 10000 Rs. over 10000 Rs. Store account of Grand Division by Superintending Circle, showing lump sums only.	Yearly list of works completed and passed by Executive Engineers according to circles. List of works completed and passed by Superintending Engineers under 5000 Rs., and under 10000 Rs. List of works in progress, showing progress in works under 1000 Rs., under 5000 Rs., and under 10000 Rs., according to circles. Comparative table of Budget allotments and expenditure. Increase and decrease in Store accounts by circles. General report.	It will be quite sufficient that there should be one Head Accountant, with assistants, with each Chief Engineer of each Grand Division, who will prepare the account required. The Chief Engineer's time, instead of being sacrificed to petty detail, will be occupied in considering extensive plans, etc., for the good of the country; consulting with his council, in order to provide for the wants of the country, and advance its prosperity in every way.

ACCOUNTS, GENERAL SYSTEM OF BUDGET, ETC.

The Executive Engineer would prepare plans, etc., for his Division—in communication with the Superintending Engineer—who, as before remarked, is answerable for the design and efficiency of all plans and designs. Under 1000 Rs. no estimate need be furnished beyond the Executive Engineer's office, only plan and simple statement of cost. No estimate under 5000 Rs. need be furnished beyond the Superintending Engineer's office. Estimates above 5000 Rs. must be accompanied by plan, estimate, and report, for consideration of Chief Engineer, which will be prepared in the Superintending Engineer's office.

The Superintending Engineer will collect all plans and schemes of his circle, and class them—according to amounts, and also as to their emergency—and be prepared to offer full information on the subject. The Council, in conjunction with the Superintending Engineer of Circles, will distribute the amount of Budget allotment made to any Grand Division amongst the Superintending Circles; taking into consideration the emergency and necessity of the works in each. When the accounts for each Superintending Circle are known, the Superintending Engineer will place the amount at the different treasuries, as may be settled by him in communication with the Executive Engineers. The Executive Engineers would at once commence work; thenceforth, all responsibility rests with them. To enable Government to judge of the sums likely to be required for each Grand Division, the Superintending Engineers of Circles would send in the sums required for their respective districts, with plans, etc., for the ensuing year; these would be considered by the Chief Engineer and Council, and the wants of the different Circles, and the urgency of their several claims be taken into consideration. The Council, in their deliberation, would have power to add to their number by calling in the aid of any Commissioner or Deputy Commissioner whose district was affected by proposed works. Such would be the general outline of duties as far as the Budget is concerned. The work in the different Grand

Divisions would, of course, vary considerably. Irrigation and Railways would entail more work in elaborating detail; and double work, inasmuch as the returns of income would have to be taken into consideration. Collection of income would, however, form quite a different branch, with which the Executive Engineer and the Superintending Engineer would have nothing to do, except that a return would be made to them from the Chief Engineer's office, showing the year's statement of cost, income, etc.,—all necessary points, in fact (in a tabular form), to enable the Executive officers to judge of the result of the work. The accounts that each officer would have to furnish will be shortly enumerated. Such of these accounts as passed through the Superintending Engineer's office would be tabulated by him: for works under 1000 Rs. he would send in the Executive Engineer's completion report, with his own remarks; for works under 5000 Rs. he would send in the statements and measurements sent in by the Executive Engineers, with his remarks made in the appropriate column; and for works over 5000 Rs. he would furnish a condensed account, showing the expenditure on each head of estimate, as far as it had gone, in a lump sum, and the column of estimated expenditure in its proper column for comparison, Form B. The Chief Engineer would have a Head Accountant with him, who would check the accounts and compare the expenditure with the Budget allotments, and prepare a report in his Department for the Chief Engineer, whose duty it would be at the end of each year to draw up a full report of his Grand Division for the consideration of the Council for suggestions or alterations. This report would then be submitted to Government. Returns of income would be sent in by the receiving officers direct to the Chief Engineer's office. The check of receipts would be the same as adopted generally for railways in England; but the officers would not be Executive Engineers. Also for irrigation works the collection would be made by the civil authorities, who would simply send in a yearly return of income to the Chief Engineer, in order to enable him to compare the results of the expenditure of his Department with the return.

ACCOUNTS TO BE FURNISHED BY STOREKEEPERS, OVERSEERS,
AND EXECUTIVE ENGINEERS, AS PER FORMS.

(See Appendix.)

We will now proceed to describe shortly the several accounts that would be necessary; and will commence with those of Storekeeper.

His accounts would be extremely simple. He would keep a list of all stores received and disbursed, with their prices; and where a quantity of articles were delivered to him in bulk, he would enter a price for retailing out per pound or hundred, or in whatever way would be required. He would also keep a daily account of stores issued, with number of receipt and name of the recipient attached. He would be answerable for all stores, and would be required to give security.

The Overseers or Foremen, by a native writer, will keep nominal roll of workpeople; receipt of all stores received for works, which will be charged at once to work; and he will measure every four or five days, or oftener, if necessary, the work done. In this he will be guided by the orders of the Executive Engineer or his assistants. These measurements must be filled in when taken, and be always ready for the Executive Engineer whenever called for, in Form G. He will cause to be kept a daily nominal roll of workpeople, which will be his voucher for the number of workpeople employed, and these lists must be kept in his office and the people paid by them. When the work has been completed and passed by the Executive Engineer or Superintending Overseer, they may be destroyed.

The Overseer must also keep a cash journal, in which all entries must be entered in the fullest and most explicit manner.

The Executive Engineer's accounts will consist of a cash journal, also a half-yearly return of receipts and disbursements. From his journal the sums would be posted against each work being carried out by himself in the ledger, also to store expenditure, and to increase of store account, salaries, etc. Overseers or native writers

would keep an account of daily expenditure on each work, including labour and materials; these the Executive Engineer would collect weekly or monthly, or at the most convenient times. For works under 1000 Rs. he would only furnish the Superintending Engineer with a completion report when *finished*: all accounts would be sent in quarterly.

For larger works over 1000 Rs. the Executive Engineer would collect the accounts in a similar way as for smaller works, either weekly or monthly, when, if possible, he or one of his assistants would measure and check work done as reported by the Overseer, and give an opinion on its value. For these works he would send in a quarterly statement of progress in Form B. The measurements in these forms should be always certified by the Executive Engineer at the end of the quarter. Every quarter also the Executive Engineer would send in a statement of cash, Form C. Half-yearly he would send in a list of stores and materials as they stood at the last half year, showing the increase and decrease and present quantities, as in Form E. Materials placed at site for use on a particular work would be charged at once to that work, and if bought or made expressly for that work would not pass through the Storekeeper's books, but would only appear in those of the Overseer; for instance, in Form B, say 50 Rs. worth of stone for masonry is received, 50 Rs. would be added to masonry expenditure, and in column of remarks would be added, increase of rate caused by stone credited but not yet used. What I would provide for is, that the Executive Engineer should have ample time to inspect the different works and do away with as much paper work as possible. When material is at once charged to work, it is easily accounted for, and not lost sight of, and prevents any complication of accounts. So for lime-burning, brick-making, etc., the Overseer would keep the nominal rolls, etc.; the Executive Engineer would check out-turn with expenditure, *his particular duty*, and he is alone answerable for the price of his materials, and he alone makes his estimates. These accounts of materials manufactured would not go beyond the Exe-

cutive Engineer's office ; he would charge the material so made to works at once, or if any surplus remained they would go to the store account ; this would seldom be necessary, however, as any surplus should at once be moved and charged to any work in progress. When I say that the Executive Engineer is alone responsible for the price of materials, it means within the limits that the Superintending and Chief Engineer may think fair. Some materials are difficult to be obtained in certain localities ; for these, the assistance of the superior officers will be required. I would here remark, that the minute detail now furnished to Government is utterly useless. If the work is good it must be evidently immaterial to Government, whether they have records of the quantity of stone, lime, etc., that is expended on any particular work, etc. They get all this now in minute detail from works costing 10 Rs. to as many lacs ; when they get it, the work is bad and the detail useless. Leave, therefore, the detail of brick, lime, and stone, etc., to the proper person, the Executive Engineer, and make him responsible for his rates and his work. Government have the estimate of the work, and the cost of its completion before them ; the statement of the Executive Engineer (a practically trained man, according to my plan) that the work is good ; also the corroborative statement, or otherwise, of the Superintending Engineer, who has been trained in the same school. If any building did not prove to be well built, the Council of the Grand Division would decide on cause of failure ; if the construction were bad, the Executive Engineer would be solely responsible ; if the design, the Superintending Engineer. They would be liable to pay the amount or lose their appointment. The accounts of the Superintending Engineer would be more simple than the Executive ; in the first place, he would not meddle with detail, except generally to satisfy himself that the rates of the various Executive Divisions under him were fair, and his whole time would be given up to the improvements of his circle, in acquainting himself with its natural features and resources ; in promoting its welfare by scheming works of irrigation, etc., and improved

methods of communication ; and reducing prices of materials by improved method of working. He should check the measurements of the Executive Engineers and see that the general affairs of their Divisions are properly carried on ; and he must himself pass all works and satisfy himself of the final correctness of measurement. He will send forward, quarterly, a list of works finished and passed by the Executive Engineer under 1000 Rs. ; also a list of works under 5000 Rs., passed by himself ; a list of works over 5000 Rs. in progress, Form B ; and statement of amounts drawn by the Executive Engineer against the Budget allotments.

The Superintending Engineer will merely certify the correctness of store accounts, and not permit of their assuming undue proportions. He will send in, half-yearly, a general report of his Circle, giving a description of the state and advance made in each Executive Division. One fruitful source of severe loss to Government has ever been the sudden withdrawal of funds from works during progress. This should be strictly guarded against, and never occur. No work should be commenced unless the sum necessary for its completion be assured. Regarding irrigation works, this cannot be too strongly insisted upon, as not only might it cause serious loss by the simple desertion of works in progress, but deviation of streams, etc., left incomplete, etc., might bring wide-spread injury ; but for any work it is to be avoided, not merely for the loss of material, etc., but also on account of the injustice often done to contractors.

There should be in every Superintending Engineer's office a Map of each Executive Division, on the scale of six inches to a mile, and plans of all towns and important villages on a larger scale. These last would not generally be necessary for the Irrigation or Railway Grand Division, but for Road and Civil Building Grand Division they would be useful. For the Irrigation and Railway Grand Division a contoured Map would be necessary. These maps would also be an useful record of advance and improvement by marking on them new roads, buildings, etc., and the sites of mines, quarries, etc., that might be discovered.

The Chief Engineer would have the accounts forwarded by the Superintending Engineer, compiled in his office according to Circles. He would, as before-mentioned, not be in any way answerable or connected with minute detail; that is chiefly left to the Executive Engineer; after him, in a lesser degree, to the Superintending Engineer. The Chief Engineer, from the accounts that reach his office, can see how matters are progressing; and he should ascertain by actual inspection the state of important works, and at the same time acquaint himself with the wants of the country. This he can do partially by tours of inspection, and more fully by consulting with Superintending Engineers of Circles, whose area of supervision are within the limits of personal inspection, if unhampered by an intricate system of accounts and harassing details.

The Chief Engineer will prepare a general report and statement of his Grand Division yearly, which he will lay before the Council; after consultation and approval of his Council it will be forwarded to Government. He will not only be able to state the exact condition of his Grand Division, but its wants and its expectations. Unharrassed as he would be by a thousand petty details and executive labours, he would be able to bring a broad and statesman-like view of the state of affairs in his Grand Division before Government. Not only could he propose works to be undertaken and projects considered, but might constantly find improvements to be undertaken in the general management of construction of certain works or the conservancy of finished projects. In a country so vast as India, with such variety of soil and climate, and with such vast undeveloped resources, a man with any brain would have far more than enough to take up all his time in the consideration of the ways and means of advancing the interests of any one of the Grand Divisions. In order, however, to give any man, however clever, a fair chance, I might say the smallest chance, of mastering any one subject, it is indispensably necessary, that his energy should be directed to one branch only of engineering; that his time should not be frittered away in detail that

does not belong to his office. The Chief Engineer having gone through the Department in one branch, should have acquired during his course of duty executive knowledge, administrative knowledge, and local and personal knowledge of the country and its wants—that should make him capable of giving really valuable advice and assistance to his Council and to Government. What we want is reality and life in the Department. It is at present more a department containing certain well paid appointments than an Engineering Department. The sound construction of works and careful preparations of projects, and speedy development of the resources of the country, are not the soul and aim of the Department; but this it must be—this it is the duty of our rulers to make it. There is another point that requires mature consideration; that is, the conservation of works in India. The conservation of buildings and roads should be kept apart from the construction branch. Civil buildings, when completed, should be kept in order by a Municipal Board, who would, of course, have professional advice, if necessary. So, also, as regards roads. I never yet saw a road really properly kept up in India. They are made and too often allowed to go to ruin before anything is done. This is very shortsighted policy; but, as I have before observed, the distances and the immense extent of one officer's charge make it very difficult to keep up half-made roads. If a road is once made thoroughly good, it is far easier and more cheaply kept in repair if under constant supervision. The only remedy is making the conservation of roads local, and having strict and stringent rules to enforce timely repairs.

To conclude: What have we really done for India? Let us not confound this with what we have done for ourselves. We have given India Railways, true—*Manchester*. We have given India the Telegraph—again *Manchester*. We have greatly increased the communication with England—again *Manchester*. Look now on the other side. Look at the ruined tanks lying buried in vast jungles. Look at the whitening bones of hundreds of thousands in Orissa, Rajpootana, and Guntoor. Look

at our public buildings, mostly disgraceful to the constructors. Where are the natives? With the exception of a few isolated individuals, we fail to find them in any of the higher Departments. In the Department concerning which I write not at all.

Have we not rather hitherto ruled India for ourselves, and not for the natives? Have we not rather kept the natives back, than done our best to train them for the most advanced posts? Has there not been an endeavour in the exclusive services to retain patronage and high emoluments for English gentlemen, rather than to desire to see the improvement of the natives, and to promote the development of Indian intellect? Not wholly so; but still I am afraid that no one can deny that patronage and place have always been an inducement to make our services exclusive, and to ignore native energy. That day is passing away. More public attention and criticism is being brought to bear on Indian matters, and we, as a nation, are awakening to the knowledge of the fact, that our policy of ignoring the native in his own land is not only shortsighted but unsafe. But more, it does not pay. The Indian taxpayer has paid £166,000 for nothing in the Saugor Barracks. He has also paid for Railways a very high price; he will have to pay still higher as iron and coal and freight increase in price in England, unless England does her duty and teaches the native to utilise the teeming productions of his own land. We are without excuse, for all who know the natives of India know right well that they are capable of acquiring quite as high an intellectual standard as we are; and if we offer them honestly and fairly the inducement, by giving them free access to the highest positions, when duly qualified, we shall find no lack of competent men.

Such is the course that I venture to recommend, and have slightly sketched in these pages. I do not pretend to put it forward as an organised scheme; but what I would impress on Indian officials and the Indian public is, that there must be, in any remodelled scheme of Public Works, a clearly defined responsibility and a simple system of accounts; that men shall be chosen for their practical

knowledge of work, and shall fall or rise by merit alone; and let us acknowledge and act up to our duty of developing native intellect and native resources as much as the protecting the pockets of the taxpayer. We are not justified in making the inhabitants of India pay exorbitant prices for iron, etc., when it lies in inexhaustible quantities at their very doors; nor are we justified in dragging her sons to England to learn a profession that must of all others affect most seriously and beneficially the physical and moral condition of India, when that profession can be better learnt in India.

In the year 1871-72, 168,049 tons of material, costing £707,765, besides £223,617 for freight, were sent to India. In 1872-73 the price would be doubled, and the price will increase year by year. This is doubtless good for English iron trade, good for English shipowners. But is it right? Are we never to rise above our old appellation, A NATION OF SHOPKEEPERS? The price of iron is now so high, and the price of coal likely to remain a difficulty, that we must perforce commence earnestly to develop the immense resources of India in this respect. Then let us manfully do our duty, however tardily commenced. Our difficulties* are removed; with a little patience and perseverance India may supply not only her own material, but work with her own brains.

Finally, there is nothing that promises so well for the rapid advancement of India as the thorough development of her iron and coal trade, and the education of her sons to work out that development. No reform of her public works will succeed without the honest cultivation of native talent and the promotion of her material resources. *Salus populi suprema lex est.*

* See Notes on Iron Works.

NOTES ON ROADS, IRRIGATION,
AND IRON WORKS.

NOTES ON ROADS, IRRIGATION, & IRON WORKS.

ON ROADS.

THE subject of roads in India is one of great difficulty; not only are they difficult in construction but in maintenance. In making they are often very expensive, for want of a proper metal or hard road material, also in many instances, such as on the blackcotton soil plains of Berar, on account of the want of good building stone within reasonable distance, and brick could not be used there on account of extremely minute particles of lime in all brick earth tried, which caused all bricks to powder as soon as wetted. The expense of bridging is also great, mullahs or brooks that seem nothing in the hot weather requiring extensive bridging to allow of the monsoon water getting free vent. The maintenance is difficult, on account of the great distance often to be traversed, without any village, through soft friable soil, where the small razor wheels of the native carts cut the roads to pieces and render them a hotch potch in the rainy season; the difficulty, before mentioned, of obtaining metal, also the great expense of supervision (I mean really useful supervision) over such immense and often unproductive tracts.

It is a question, and one well worthy of the most serious consideration of Government, whether it would not be better and more profitable to construct light railways over all the trunk roads; whether if iron railway mills were established, together with works for the construction of engines, etc., they could not be made at a profit.

As matters now stand, the main lines of roads are not good,* in fact in very many places very bad, and in some

* See paragraph 328, page 136, Report on Public Works, Bengal, Madras, and Bombay, *Parliamentary Papers*, 407, I.

there are roads only in name. These roads cost Government large sums to maintain, and you may say there is no return whatever from them, whereas if a light railway were constructed there would at all events be some return, and the gain would be immense, not only in an improved method of transport but in speed. If these lines only paid their working expenses and a small interest, it would be far better than the present incomplete and inefficient system, and the interest of their primary cost would not entail anything like the present expenditure for a very inefficient maintenance. As I have remarked in my note on iron the discovery of coal has removed the great difficulty in the manufacture of iron, and the Bessemer process does away with another difficulty. With an energetic system there does not seem any difficulty in spreading a network of tramways along the whole of our trunk roads. Steel rails made by Bessemer's process will soon become universal, and they will wear out twenty of common H-rails, *turned*, that is both sides used. *The question* concerning Indian railways appears to me to be the use of wooden sleepers; they are found to give the best results, but in a climate like India, subject to extreme wet and extreme dryness, and attacks from white ants and other insects, the discovery of a less destructive material would seem desirable; yet Barlow's patent, and several others that I have tried or seen tried, do not seem to be approved of so much as the old wood. If iron and coal could be worked cheaply in India I would say that perhaps rail and sleeper rolled in one would answer best, or heavy cast iron sleeper and rail, the rail being cast with a cold chill at top that hardens the surface like steel. It is a matter that requires much consideration, as the use of wooden sleepers will yearly become more expensive, and also the maintenance of the lines. Government would do well to offer a reward for the best method of laying rails with the most lasting description of sleeper. We may yet use paper sleepers if the new process fulfils its promise.

For cross roads and all branch roads not included in the trunk roads, it will be necessary to raise a cart tax, with a heavy tax on all wheels under a certain breadth. This

tax was raised in Salem, in the Madras Presidency for many years, *vide* para. 475, p. 198, Parliamentary papers I. It seems at first to have been a voluntary contribution of the cart owners of one rupee per cart, to form a fund to keep the roads in order, and as remarked by the committee in par. 682, "It would be no hardship on the 56,000 villages comprised in this presidency to oblige them to make and maintain 150,000 miles of cross road for their use and convenience."

Such roads should also be kept in repair and supervised by officers under a local or municipal board, and the executive officers should be paid exclusively from local funds. If railways could be formed, Government would find no difficulty along the main lines at least of disposing of them to private companies under proper regulations, and thereby relieve themselves of much labour. To arrive at the exact cost of keeping roads in repair seems extremely difficult; no doubt in some measure owing to the great variety of roads as known in India, from the Dak line well metalled and thoroughly bridged, to the track, perhaps just marked out. The cost ranges, as taken from various authorities, from 350 rupees a mile to 3,000; if we take the mean we shall not be far wrong in saying 1,600 rupees a mile. This would keep a road subject to extremely heavy traffic in good order. A tramway on any of the main Dak lines in India would cost, including engines and plant,* 30,000, supposing most of the bridges to be available and the gradient generally serviceable; the interest on 30,000 rupees a mile at 4 per cent. would be only 1,200 rupees, and the improvement in transit would be extreme both in a commercial and military point of view.

ON IRRIGATION.

A general system is much wanted which shall deal with the irrigation department of India by itself. There is ample room for such, and it has often been proposed, but never *thoroughly* carried out. The department would

* This, with English iron—with iron made in India, it should be 25 per cent. cheaper.

naturally divide itself into two heads : 1st. Channels of irrigation from rivers and annicuts. 2nd. Tanks of irrigations. There are at the present time, you may say, nearly all the large rivers of India untouched. Some have annicuts across them in the delta portions, but all the higher portions pour down huge volumes of water, often in dangerous torrents, which sweep unchecked high over the annicuts into the sea. Much of this valuable commodity, priceless in India, might be taken off into tanks; much of the water, where it debouches from the hills, might be stored in immense reservoirs; in fine, such a quantity of water might be accounted for and deviated from the main channel as to prevent any extremely disastrous flood.

The works would be difficult of construction on account of the quantity of water to be dealt with, and in many instances on account of the nature of the soil and substrata; the undertaking would require much thought and skill; but that is the legitimate work of engineers.

Under the Himalayas, between the main hills and the subsidiary line of hills, there should be sites for reservoirs that might be turned to useful account. Our engineers would do well to study some of the large tanks made by natives hundreds of years ago, and then go and plan larger ones, more suited to present wants and our supposed advanced stage of science.

There are still vast arid places in India only waiting for the formation of irrigation channels to burst into fruitful fields. There are hundreds of tanks, I might say thousands, that require repair, and many more are wanted. But why repeat what has been reiterated again and again by earnest men for the last fifty years? No one can *deny the want*. But hitherto we have not had the practical means, nor have we been alive to the want of a really living engineering department.

With such vast areas we must, however, take the greatest care that the labour is properly divided. The irrigation department would be simply constructive, the conservative department must be left to local and municipal boards under the revenue authorities, having the pro-

fessional assistance of an engineer, who might be supplied from the department.

The construction of any large number of tanks would be now very expensive, and to make one of great magnitude requires peculiar features in the contour of the ground not commonly met with. The instruction of the natives in scientific engineering knowledge, and their admission into the highest ranks of the department, would probably lead to a more earnest perception of the necessity of storing water and a greater confidence in the profitableness of such undertakings, sufficient to induce the natives of India to embark their capital (now too often lying idle) in such speculations.

We have given India railways and electric telegraphs, great boons no doubt; but are they unqualified ones? The tendency has been hitherto to raise the price of labour 50 per cent., the price of food in some instances 200 per cent. The means of carriage has enabled rich merchants to export large quantities of grain from the country immediately around them, and bring in cheaper grain from outlying districts,* making large fortunes in a few years. It would seem that higher stages of civilization, accelerated communications, and increased traffic, bring with them greater wealth to the few, and greater difficulties to the masses. This is scarcely desirable. At the same time that we look to Manchester and our own interests, do not let us forget the teeming millions of poor cultivators in India, who formerly cried to their native rulers for water and got it, who have been crying to us for the last fifty years for the same boon—and lo! we give them railways. Our prosperity must, however, finally rest on the masses, and it will pay better in the long run to look after the riots and give them water and cheap food; and then let them pay for their railways and other luxuries by local taxation out of their increased prosperity.

* In 1844, in Raepoor, 160 seers (2 lbs.) of grain could be bought for one rupee; in 1865, only 10 seers could be bought for the same money.

ON IRON WORKS IN INDIA.

I have before referred to Iron Works. They form, indeed, one great feature in my plan. The system of railways is now very extensive, and it is to be hoped that tramways may soon be even more so; it therefore becomes a necessity that the resources of India as regards Iron Works should be at once developed. You have now coal. In the Presidency of Bengal alone there are forty-four coal mines at work, and of these there are nineteen each turning out more than ten thousand tons a year, and every year the quantity is increased. The locomotives of all the railways that run to Calcutta, and also the steamers on the Ganges, etc., now burn Indian coal. The want of coal has hitherto been the great drawback, but now that we have coal and an ever increasing system of railways it is absolutely necessary that Iron Works should be established. The first desideratum in establishing an iron manufactory is the proximity of the iron and coal. Porto Novo, south of Madras, failed chiefly on this account. It was far from its sources of supply of iron ore, and also of fuel, and that fuel was ill-adapted for the reduction of iron ore in large quantities. The only thing that could have saved the Porto Novo works would have been the working of the coal at Mergui, across the Bay of Bengal, and the use of three or four screw colliers to keep up a constant supply. The exposed character of the Porto Novo roadstead was against it.

The means of carriage from the banks of the Cauvery for its raw materials were most inefficient. Mr. Norfor, manager of the Porto Novo Iron Works of the Indian Iron Company, in September, 1851, writes: "The reason that this canal does not come into more general use is because no dependence can be placed on it. Boats go up to fetch produce, but are by no means certain when they may be able to return." Again, "the land is impassable, and the roads are not much better in the wet weather; the consequence is the collector has much trouble in collecting the revenue, because the paddy is stored in the fields, whereas with a more easy mode of transit it would be immediately

forwarded to a market." Since that was written, and since the Indian Iron Company struggled for existence, great improvements in means of conveyance and great discoveries of coal and iron have been made. Any new undertaking would start under very different auspices.

The primary object would be, after the production of iron from the ore, to manufacture it into its most useful forms. The great drawback that always struck me was the difficulty there would be to obtain a constant supply of puddlers. This is now done away with by Bessemer's process. This process especially recommends itself for development in India. Mr. Bessemer, after years of labour and after the most extraordinary patience under difficulty and ridicule, has manifested the importance of his invaluable invention. Rails made by Bessemer's process would be one of the most useful and lucrative branches that could be undertaken. In Dr. Ure's *Dictionary of Arts, Manufactures, etc.*, we find a comparison recorded of the relative value of iron and steel rails.

"Thus we find at the date of the last report on March 1st, 1865, that *seven* rails had been entirely worn out on both faces. Since then another rail has been worn out up to July, making *sixteen faces* worn out, the *seventeenth* face being in use on August 22nd, when the *steel* rail that had been placed opposite to them was taken up in the presence of the writer, and, by the kind permission of Mr. Woodhouse, now lies on the table before the meeting. The *first face* of the rail only has been used, and this is now become much thinner than it was originally, but in the opinion of the platelayers is still capable of wearing out another half dozen faces. Taking its resisting powers at *three* more faces only, it would show an endurance of *twenty to one* in favour of steel." Manufactories also for rolled girders for bridges, iron castings, railway chairs, Potts' iron piles, screws for screw piles (most useful for bridges over sandy rivers), all these should be made. In the fitting department locomotives and stationary engines and fittings for railway carriages, etc. It might be found expedient to encourage the native production of wrozt iron, buy it up, faggot it under the steam hammer, and

form it into bars and rods for any purpose where the best iron is required. Such iron I imagine would find a ready sale among gun-barrel manufacturers in England and Germany. For many years, however, India would consume all the iron that could be turned out. The present iron establishments are a mere drop in the ocean. The establishment by Government of our manufactories on a scale commensurate with the wants of this country, I consider at the present moment the most important step towards the formation of a proper system of Public Works. Whether such works would remain in the hands of Government or not would not matter. Such works would always be a nursery available for mechanical engineers, and in their proper place for the instruction of the natives of India. It is not only the duty of instructing the natives of India that points out the desirableness of establishing iron works, but also the remarkably good quality of its iron ores. It can require no argument from me to show the extreme importance of commencing iron works on a large scale under the auspices of Government, in order to initiate on a broad basis so desirable an industry into India. Nor need I more than point out the immense saving in cost price, and also in freight on iron. For our present railways (not counting lines now making or to be made)—it would require to relay these 800,000 tons of rails alone, or about £9,000,000 sterling as cost price in England. 8,500 tons of iron for two bridges in India over the Chenab and at Agra are now going out from England. Here we expend £80,000 cost price in England for that which could be better made and cheaper by at least one-third in India, and we send metal from England to a land teeming with iron ore in its richest forms. Should this be?

Late inventions and late discoveries have entirely cleared the road for us. The discovery of coal in large quantities, and the invention of Bessemer's process have removed all difficulties. There is no undertaking in the world that would pay as well as properly established Iron Works in India.

Another invention that is worthy of notice is Howard's

patent boiler ; it possesses many properties highly valuable for Indian use. Its extremely portability, the ease with which additional power can be added, the ease with which it can be cleaned, and its perfect safety, and last, not least, its great economy in fuel, point it out as one of the best inventions of the day. Let any one calculate the quantity of iron imported into India since 1865, some millions of tons, about 4,400,000, costing about thirty millions. The railways alone would take above one million for permanent way. Then calculate the loss that will accrue to India if the same loss is to be borne by her for the next seven years, loss in cost price, in freight, in inland carriage. Iron is now certainly one-third dearer than it was, and it is not likely to become cheaper. As I have pointed out above, by recent discoveries and inventions there is nothing absolutely stands in your way, and I repeat it is time, full time that our rulers were alive to the great importance of the establishment of Iron Works in India commensurate with the wants of the country and the vastness of her Public Works. On such works must greatly depend the rapidity or otherwise of the advancement of India.

Nor must we lose sight of the immense advantage to England in a military point of view of the establishment of Iron Works in India. The iron of India is particularly pure and particularly suited to Bessemer's process, and all experiments tend to prove that iron made by his process possesses greater tensile strength than the iron used in our heavy guns. We may in the course of a few years be forced to have a large army on a war footing, and have to erect batteries and collect war materials along an extensive frontier ; let us then learn in time to make use of those valuable materials *that nature has thrown at our feet*, not only in the raw material of India, but in her intellectual resources. We may find both useful in after years.

The supply of iron is inexhaustible ; your coal is sufficient. Let us just glance at what is before us. A country whose area is about 1,300,000 square miles, with a population of 200 millions ; taking twelve only of her largest

rivers, namely, the Indus, Sutlej, Brahmapotra, Ganges, Jumna, Gunduck, Godavery, Rhisna, Nerbudda, Mahanuddee, Taptee, and Cauvery, you have 11,000 miles of river bed, you have 5,500 miles of railway, and nearly 15,000 miles of telegraph. With all this have we done a half or a quarter, or even one-eighth of what we have to do ? and we cannot do what we have to do unless we exert ourselves to develop Indian resources. Forty per cent. of the cost of those railways has been expended in England, or about thirty-five millions. Great Britain has a mile of railway to every 2,000 souls, and to every eight square miles of area ; India at present one to only every 46,000 souls, and to every 2,000 miles of area.

Our railway bridges call for considerable change in construction ; the late disasters show that nothing like sufficient water way is allowed, and for this the only remedy is to use iron lattice or Warren's patent girders, and iron cylinders for piers. Iron will give us the greatest spans and iron columns present the best resistance to floods.

I would here remark that I consider the reduction of the guage for railways a great mistake. The difference in earthwork, in weight of rails, in cost of bridges is very slight ; the difference is chiefly in rolling stock ; this is also not very great, but I consider all this is far overbalanced by the increased weight that each truck is able to carry in the broad guage, and this is of great importance when the general character of Indian goods is taken into consideration, goods that are bulky for their weight. However that may be, the fact alone of break of guage is most serious, and this will be found every year as junctions and branch lines increase. The great object must always be to prevent *manipulation* of bulky and heavy goods, and except for purely local purposes such as a stone quarry or coal mine (except these even when in direct communication with railway) there is no such thing as a light or cheap railway.

Bessemer's process, in giving us steel easily and quickly made, will greatly reduce the weight of iron, and if made in India, at a greatly reduced price from present English prices. For our Indian railways and tramways,

for our river navigation, for our telegraphs, for our buildings and bridges, we must have iron. The high rates in England will force you to use the Indian iron: the sooner, therefore, you commence to put the working on a solid and business-like basis the better.

As I have before observed, I consider these works should be initiated by Government. My reasons are that to induce any company to commence such an undertaking on a scale commensurate with our wants would necessitate the granting of such terms by Government as must be prejudicial to Indian development for many years. The Indian Government being nearly the only or chief consumer the price of iron would be kept up far beyond its proper value. If Government should institute an iron work in a well chosen and central position, and erect blast furnaces and Bessemer's machinery for railway iron, I believe the cost of the present freight from England and inland carriage would pay for the iron. The rails would be lighter and more durable, as twenty to one.

APPENDIX.

FORM X.

PROGRESS.

DETAILS.	No.	DIMENSIONS.			Content of Area.	Total.	Grand Total.	Reported done at end of last month.	Balance work done during the month.
		L.	B.	D.					
EXCAVATION.									
Wing Wall	2	15	7	2	420	420	420	.	420
Foundation Abutments	2	24	5	6-6"	1560	1560			
Ditto	1	24	7	2	336	336	1896		1896
Filling Foundation Stone in Chunam	1	24	6	2-6"	360	360			
Ditto	3	24	5	2-6"	900	900			
Ditto	1	24	6	1-3	180	180	1440		1440
Filling Foundation Wing Wall in Chunam	2	4-8	6	4-9	266	266			
Ditto	2	4-8	4	4-9	177	177			
Ditto	2	4-8	3	4-9	133	133	576		576
Abutment Dressed Stone in Chunam	1	24	5	3	360	360			
Ditto	1	23	4-6	1-9	181½	181½			
Ditto	1	24	4-6	3-8	396	396			
Ditto	1	23	3-8	1	84½	84½			
Abutment Piers in Chunam	2	2	2-3	3-8	33	33			
Ditto	1	24	4-6	3	324	324			
Ditto	1	23	3-8	6"	42½	42½			
Ditto	2	2	2-3	3	27	27			
Ditto	1	24	4-6	5-9	621	621			
Ditto	2	2	2-3	5-9	51½	51½	2120½		2120½

N.B.—The progress must be explained in words if it cannot be given in figures. Always state whether the work is completed, or if more still remains to be done.

Daily Account of Expenditure on Bridge over ——— Nullah

(A.) The main divisions of the Estimate, as foundation, superstructure, red painting, etc., etc., should be entered here.

FORM X.
during the Month of

186 .

Superstructure.														
Dressed Stone in Chunam.														
24	Hire, Grading Chunam & A. p. day.	12	0	0										
22	Black-mith at 6 Aa. per day.	8	4	0										
91	Coolies at 3 Aa. per day.	17	1	0										
52	Coolies at 1 A. 9 P. per day.	5	11	0										
112	Bullocks, pair feeding at 6-8 each.	46	8	8										
		275	7	6										
2000	Stones dressed at 10 Rs. per 100.	200	0	0										
242	Cft. Chunam at 37-8 per 100.	66	8	9										
11	Cut-Water Stones, each 1-4.	13	12	0										
32	Corner Stones, each 1-8.	48	0	0										
100	Header's Stones, at 20 Rs. per 100.	20	0	0										
8000	Gross, at 4 pr. 1000	32	0	0	380	4	9							
ABSTRACT OF LABOUR AND MATERIALS.														
Excavation :—														
Labour ... 42 11 6 42 11 6														
Stone in Chunam :—														
Labour ... 114 0 5														
Materials ... 222 1 2 386 1 7														
Stone in Chunam :—														
Labour ... 275 7 6														
Materials ... 380 4 9 655 12 8														
Total Genl. Rupees 1034 9 4														
[The materials should be entered above; it is not necessary to enter them also in the Figured Abstract.]														

(B.) The minor sub-divisions of work, as excavating for foundation, plain masonry, pumping out water, etc., etc. (all belonging to the head FOUNDATION); masonry, scaffolding, etc., etc. (all belonging to the main head SUPERSTRUCTURE); and so forth, should be given in this column.

REMARKS

FORM X.

AND

FORM No. 33 (Page 124).

EXPLANATIONS. _____ *Division.*_____ *Station.**Month of* _____ 186 .*Day Book of Expenditure on*

AUTHORITY.

Estimate No. _____ *of**Letter No.* _____ *of**dated*

N.B.—Fill up whichever of the two above is applicable; if neither is, insert instead the actual authority on which the work was undertaken. If there be none, say so.

Items.	Labour.			Materials.			Total.		

[The above Table should be left blank for the Central Office to fill up.]

*Overseer.**Executive Engineer.*

N.B.—Signature of the Overseer, and counter-signature of the Executive Engineer, to be only on the back above.

FORM A.

FOR WORKS UNDER 1000 Rs.

NOTE.—This Form will be sent in by Executive Engineer on completion of Work only ; he will, however, keep regular Ledger of Work during progress.

Bridge No.

Estimate No. 900 Rs. D. _____

On No. _____ Mile of _____ Road.

Commenced by Overseer (date _____).

Finished by _____ (" _____).

Passed by Executive Engineer (" _____).

Description.	Estimated Cost.		Actual Cost.		Increase.		Decrease.		Reason for Increase or Decrease.
	Bs.	Pie.	Bs.	Pie.	Bs.	Pie.	Bs.	Pie.	
Masonry ...	200	...	...	...	...	...	50	...	{ Stone close at hand and easily wrought.
Archwork ...									
Cutstone ...									
Paving ...									
Roadway ...									
Approaches ...									

Signed _____ Executive Engineer.
 " _____ Superintending Engineer.

FORM B.

Sent in by Executive Engineer. Measurements proved by Superintending Engineer and countersigned by him.
Foolscap.

Quarter ending _____
 Progress of Bridge, No. _____ on Road, No. _____
 Estimate No. _____ for 10,000 Rs. D. _____
 Commenced (date _____). Finished (date _____).
 Passed by _____ (date _____).

Description.	Quantity in Estimate.	Cost.		Quantity done to date.	Cost.		Increase in Rate.	Decrease in Rate.	Remarks.
	Cubic Yds.								
Foundations :									
Masonry ...	200	1000	...	200	950	...	...	50	
Superstructure :									
Masonry ...	1200	6000	...	1000	6025	...	25 Rs.	...	
Archwork :									
Brick ...	20	200	...	10	100	...	...	...	In progress.
Etc., etc., etc.									

Signed _____ *Executive Engineer.*
 Countersigned _____ *Superintending Engineer.*

FORM C.

HALF-YEARLY RECEIPTS AND DISBURSEMENTS OF THE EXECUTIVE ENGINEER, _____ DISTRICT.

Ending Half Year (date _____).

RECEIVED.	AMOUNT.		PAID.	AMOUNT.	
From Treasury at _____	10000		On Estimate No. _____	500	
” ” _____	5000		” ” _____	2000	
” ” _____	5000		” ” _____	10000	
From Miscellaneous Sources	50		Paid Overseer	5000	
			” ”	50	
			” ”	50	
			Salaries	50	
				1350	
Total Receipts	20050		Total Disbursements	19000	
			Balance in hand	950	

F

Signed _____ Executive Engineer.

FORM D.

CASH JOURNAL.

Every item to be succinctly and fully entered, with dates, etc., and reference to estimate and vouchers. Extract sent in Quarterly by Executive Engineer. Each side. *Full sheet.*

December 18

Date.	RECEIPTS.	Rs.	Ans.	Pie.	Date.	DISBURSEMENTS.	Rs.	Ans.	Pie.
1. {	Received from Treasury on order, No. _____ D. _____	5000			12. {	Paid to workpeople wages from 1st to 8th December, foundations, Estimate No. _____ D. _____, as per Nominal Roll, marked _____	100		
6. {	Received from Sale of Old Iron, being broken pieces of columns sent from Artillery Shed, Estimate No. _____ D. _____	10			14. {	Paid for Lime, 20 barrels, delivered by _____ for Estimate No. _____ D. _____; Contract No. _____ D. _____	20		
					22. {	Paid for 1000 cubic feet of Stone, quarried by Department, for Estimate No. _____ D. _____, including carriage and all costs as per Accounts of Overseer.	50		

To be furnished Half-Yearly by Storekeeper and vouched for by Executive Engineer.

Full sheet.

[illegible]

FORM F.

To be kept by overseer; each side. *Full Folio*.

CASH JOURNAL OF OVERSEER.

Date.	RECEIPTS.	Rs.	Ans.	Pie.	Date.	DISBURSEMENTS.	Rs.	Ans.	Pie.
	Received from Executive Engineer, Order No. _____ D. _____	200				Paid labourers as per nominal roll No. _____ D. _____ for Estimate No. _____ D. _____ Page _____ Ledger. _____ Etc., etc., etc.	120		
	Received from Executive Engineer, Order No. _____ D. _____	500							

FORM G.

To be kept by overseer, and filled in daily or otherwise, as may be ordered. *Foolscap.*

ESTIMATE No. _____

Of _____ Road _____ 800 Rs. _____

Commenced _____ Finished _____

Months and Date.	No. of Labourers as per Nominal Roll.	AMOUNT.			Material as per Ledger.	AMOUNT.			Estimate Quantity.	AMOUNT.			Remarks by Overseer.	Remarks by Executive Engineer.
		Rs.	Ana.	Pie.		Rs.	Ana.	Pie.						
1	200	25		Stone, 500 cu.ft.	25			Founda- tion, cu. ft. 2000	200					
2														
3														
4														
5														
6														
7	260	38		Stone, 20 B.	10									
8														
9														
10														
11														
12														
13														
14														
15	63			20 B.	5									
16														
17														
18														
19														
20														
21														
22														
23														
24														
25														
26														
27														
28														
29														
30														
31														
				Stone, cu.ft. 500	25									
				Stone, 800	40									
				Lime, 20	10									
				Sand, 40	10				200			Finished		

FORM H.

To be kept by overseer, etc. ; each side. *Full Footscap.*

LEDGER.

ESTIMATE No. _____ FOR Rs. _____ D.

Receipts.

Disbursements.

Date.	DESCRIPTION.	Rs.	Ans.	Pie.	Date.	DESCRIPTION.	Rs.	Ans.	Pie.
	500 cubic ft. stone removed from Bridge No. _____ Estimate No. _____ for Bridge No. _____, as above.	25				To stone removed from Bridge, No. _____ Estimate No. _____	25		
	Received, as per Cash Journal, for Lime.	100				Lime from Contractor, 20 barrels, 5 Rs., Contract No. _____ D.	100		
	Received from Storekeeper 100 cubic ft. wood, 3 Rs. per cubic foot. Receipt No. _____ D.	300				To wood from Storekeeper, on Receipt No. _____ D.	300		
	Received from cash for stone, as per Journal, on Contract, No. _____ D.	250				Stone, 5000 cubic feet, at 5 Rs. per 100, Contract No. _____ D.	250		

FORM I.

For Superintending Engineer; to be furnished yearly; one for each Executive Division.

Works completed and commenced in the year. Works under 1000; Works under 5000; Works over 5000.

No. _____ EXECUTIVE DIVISION.

MR. _____ EXECUTIVE ENGINEER.

ESTIMATES.	AMOUNT OF ESTIMATE.			When Commenced.	When Completed.	ACTUAL COST.			Remarks by Superintending Engineer.
	Rs.	Ans.	Pie.			Rs.	Ans.	Pie.	
CLASS I, Under 1000. Bridge No. _____ on _____ mile _____ Road Estimate No. _____ D. _____	500			20 May 18 _____	10 Dec. 18 _____	480			
Toll House, Estimate No. _____ D. _____ Etc., etc., etc.	600			1 May 18 _____	20 March 18 _____	602			
CLASS II, Under 5000. Two miles road, Estimate No. _____ D. _____ Etc., etc., etc.	5000			2 March 18 _____	2 Dec. 18 _____	4900			
CLASS III. Over 5000. Bridge over _____ River, No. _____ Mile Road, Estimate No. _____ D. _____	20000			1 Jan. 18 _____	In progress	18000			See Progress Report. Form B.



